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COMPARATIVE EVALUATION OF PHYSICAL AND CHEMICAL PARAMETERS OF SEWAGE WATER FROM SOME SELECTED AREAS IN PORT- HARCOURT METROPOLIS, RIVERS STATE NIGERIA.

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ABSTRACT
The sewage water from some selected areas in Port-Harcourt metropolis has been studied. The various parameters studied include the physical parameters (pH, conductivity, total dissolved solids and total suspended solids), chemical parameters (dissolved oxygen, total hardness, salinity, chlorine) and metals (Pb, Cd, Fe, Mg, Ca, K).The pH of the samples ranged from 7.67 ± 0.006 – 9.18 ± 0.008. Total dissolved solids ranged from 408.50 ± 0.003 – 1050.30 ± 0.270 mg/l. Total suspended solids ranged from 17100.00 ± 0.230 – 544400.00 ± 0.430 mg/l. The conductivity of the samples ranged from 657.60 ± 0.300 – 1420.00 ± 0.500μs/cm. The salinity concentrations ranged from 342.200 ± 0.040 – 601.250 ± 0.650 mg/l. The total hardness of the samples analyzed ranged from 1098.600 ± 0.300 – 2603.120 ± 0.500 mg/l. Dissolved oxygen was absent in the entire sample studied. The chloride contents ranged from 280.500 ± 0.120 – 987.670 ± 0.045 mg/l. The concentration of Pb ranged from 0.269 ± 0.006 – 2.300 ± 0.002 mg/l. The concentration of Cd ranged from 0.013 ± 0.001 – 0.660 ± 0.002 mg/l. The concentration of Fe ranged from 80.500 ± 0.500 – 267.070 ± 0.250 mg/l. The concentrations of Mg ranged from 60.610 ± 0.200 – 167.320 ± 0.320 mg/l. Calcium content ranged from 86.700 ± 0.160 – 257.800 ± 0.240 mg/l. The concentration of Potassium ranged from 76.200 ± 0.100 – 117.000 ± 0.650 mg/l. Most of the physical and chemical parameters of sewage water exceeded the ISI permissible level. With the results of this investigation, sewage water should not be disposed into the environment or be used as irrigation water for agriculture.

KEYWORDS: sewage, domestic activities, physical and chemical parameters.

INTRODUCTION
Pollution of land, rivers and streams by sewage has become one of the most crucial environmental problems of the 21st century. The rapid development of urbanization and industrialization led to the rising use of sewage for agricultural land irrigation and water pollution. Sewage provides water and valuable plant nutrients; it leads to the potential accumulation of heavy metals in agricultural soils (Abdel- Sabour, 2003; Zhang *et al.,* 2008; Maldonado, 2008).

The disposal of sewage sludge on soils as a fertilizer for agriculture or as a regenerative for soil is the most attractive application since the sludge act as a source of nutrients for crop production owing to their high content of organic matters (Walter *et al.,* 1994). Sewage is made up of excrement, excreta, wastewater from cloth washing machines, waste from kitchen dishes, bathing water, paper fiber, food particles, vomit, garbage, e.t.c. They also contain dissolved oxygen (DO) which includes: Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Oxygen Demand Index (ODI), Total Oxygen Carbon (TOC), nutrients and heavy metals. Nitrogen and phosphorous compounds are present in significant amount in all domestic wastewater. They come mainly from human’s excreta and also from detergents (Gupta *et al*., 2008).

Domestic pollutants associated with organic matter inorganic dissolved solids and other unwanted chemicals cause serious ground water problems (Tyagi, 2000). During the past decade, widespread reports of ground water contamination have increased public concern about drinking water quality (Yanggen and Born, 1990).The sewage water gets accumulated in the form of stagnant water and if there are any drinking water pipes near to that area, there is a chance for the intrusion of sewage water in drinking water pipelines.

Heavy metals accumulate in the environment in various geochemical form i.e. water soluble, exchangeable, carbonate- associated, Fe – Mn oxide – associated, organic – associated and residual forms (He *et al*., 2005;

Cuong and Obbard, 2006). Heavy metals can be actively bound by living microorganisms by means of the following mechanisms: intracellular accumulation, extracellular precipitation and chemical transformations catalyzed by these microorganisms, such as oxidation, reduction, methylation, dimethylation e.t.c.

The toxicity and the mobility of heavy metals in soils depend not only on the total concentration, but also on their specific chemical form, binding state, metal properties environmental factors and soil properties like pH, organic matter content (Nyamangara, 1998, Lu *et al*., 2003). Excess heavy metal accumulation in environment is toxic to humans and other animals. Exposure to heavy metals is normally chronic (exposure that exceed the permitted threshold), due to food chain transfer. Acute (immediate) poisoning from heavy metals is rare through ingestion or dermal contact.

Therefore, this present study was aimed to determine the physical and chemical parameters of sewage water from some selected areas in Port-Harcourt metropolis, Rivers State, Nigeria.

MATERIALS AND METHODS.

Sample Collection and Preparation.

Eight samples (4 samples from pit and 4 samples from ground) of sewage were collected in plastic bottles from four different locations in Port Harcourt metropolis, Rivers state in the month of September, 2010. The samples were labeled as follows: Aa, Ab, Ba, Bb, Ca, Cb, Da, and Db. Where A, B, C and D represent the locations, Choba , Rumuokoro, Rumuola and Rumuokwuta respectively, a and b represent pit and ground sewage respectively. The collected samples were analyzed within 24 hours.

Sample analysis

Determination of pH and conductivity: The pH and conductivity of the samples were measured by using the electrometric methods (pH meter Jenway 3015 and conductivity meter 4010 respectively). Chemical and physical parameters of the samples were determined by standard methods (APHA, 2000; Trivedy and Goel, 1984).

Metal analysis

The eight samples were dried in an oven at 105 ^{o}C for 24 h and then ground in a mortar and pestle to a fine powder. In the PTFE beaker of a pressure reactor, 0.5 g of powdered sample were placed and 5 ml of HNO_3 (60% m/m) and 5 ml of $HClO_4$ (60%m/m) were added. The reactor was closed and heated at 150 °C in an oven for 12 h to digest the sample. The final digest was then evaporated nearly to dryness, after which some de-ionized water was added and the solution was transferred into a 100 ml calibrated flask and diluted to volume with de-ionized water. Metals were determined by atomic absorption spectrometric (Fe, Pb, Cd, and Mg) and flame photometric methods (Ca and K).

RESULTS

Table 1. Physical parameters of sewage water from some selected areas in Port Harcourt metropolis, Rivers State

Sewage Sample and locations	pH mg/l	TDS mg/l	TSS mg/l	Conductivity µs/cm
Choba Town				
Aa	8.12 ± 0.005	950.32 ± 0.012	18800.00 ± 0.250	1304.50 ± 0.300
Ab	7.67 ± 0.006	550.56 ± 0.004	476010.00 ±0.050	797.00 ± 0.200
Rumuokoro				
Ba	9.18 ± 0.008	780.50 ± 0.024	23006.50 ± 0.500	1087.40 ± 0.600
Bb	8.45 ± 0.005	408.50 ± 0.003	544400.00 ± 0.430	657.60 ± 0.300
Rumuokwuta				
Ca	8.62 ± 0.005	1050.30 ± 0.270	17100.00 ± 0.230	1420.00 ± 0.500
Cb	8.01 ± 0.012	578.00 ± 0.008	485550.00 ± 0.300	893.50 ± 0.600
Rumuola				
Da	7.93 ± 0.040	876.30 ± 0.043	19960.50 ± 0.300	1194.30 ± 0.400
Db	7.64 ± 0.009	501.20 ± 0.076	490010.00 ± 0.200	708.00 ± 0.120

Where: Aa = Choba Pit sewage Ab = Choba Ground Sewage
Ba = Rumuokoro Pit Sewage Bb = Rumuokoro Ground Sewage
Ca = Rumuokwuta Pit Sewage Cb = Rumuokwuta ground Sewage
Da = Rumuola Pit Sewage Db = Rumuola Ground Sewage

Note: all the abbreviations have the same meaning through out the work.

Table 2. Chemical parameters of sewage water from some selected areas in Port Harcourt metropolis, Rivers State

Sewage Samples and locations	Cl mg/l	Salinity mg/l	Total hardness mg/l	DO mg/l
Choba Town				
Aa	745.510 ± 0.050	541.300 ± 0.230	2302.070 ± 0.320	NIL
Ab	430.300 ± 0.015	443.000 ± 0.180	1520.230 ± 0.200	NIL
Rumuokoro				
Ba	540.500 ± 0.008	468.600 ± 0.450	1987.200 ± 0.050	NIL
Bb	280.500 ± 0.120	342.200 ± 0.040	1098.600 ± 0.300	NIL
Rumuokwuta				
Ca	987.670 ± 0.045	601.250 ± 0.650	2603.120 ± 0.500	NIL
Cb	506.500 ± 0.100	454.500 ± 0.100	1760.850 ± 0.230	NIL
Rumuola				
Da	580.600 ± 0.340	513.800 ± 0.200	2122.250 ± 0.400	NIL
Db	440.610 ± 0.040	421.000 ± 0.030	1301.170 ± 0.005	NIL

Table 3. Metals Concentrations of sewage water from some selected areas in Port Harcourt metropolis River State

Sewage Sample and locations	Pb mg/l	Cd mg/l	K mg/l	Ca mg/l	Mg mg/l	Fe mg/l
Choba Town						
Aa	2.300 ± 0.030	0.070 ± 0.001	104.620 ± 0.230	201.500 ± 0.200	135.200 ± 0.100	225.420 ± 0.009
Ab	0.440 ± 0.004	0.040 ± 0.001	76.200 ± 0.100	113.400 ± 0.150	60.610 ± 0.200	80.500 ± 0.500
Rumuokoro						
Ba	0.269 ± 0.006	0.017 ± 0.001	89.340 ± 0.320	173.700 ± 0.360	98.510 ± 0.200	135.560 ± 0.302
Bb	0.460 ± 0.005	0.023 ± 0.002	84.050 ± 0.023	94.200 ± 0.250	87.600 ± 0.200	98.410 ± 0.056
Rumuokwuta						
Ca	1.450 ± 0.002	0.660 ± 0.002	117.000 ± 0.650	257.800 ± 0.240	167.320 ± 0.320	267.070 ± 0.250
Cb	0.980 ± 0.001	0.047 ± 0.003	87.850 ± 0.343	86.700 ± 0.160	79.980 ± 0.170	89.340 ± 0.030
Rumuola						
Da	3.450 ± 0.002	0.039 ± 0.003	98.400 ± 0.002	195.400 ± 0.187	112.450 ± 0.260	187.350 ± 0.180
Db	1.090 ± 0.002	0.013 ± 0.001	80.900 ± 0.200	104.420 ± 0.260	70.415 ± 0.340	87.850 ± 0.200

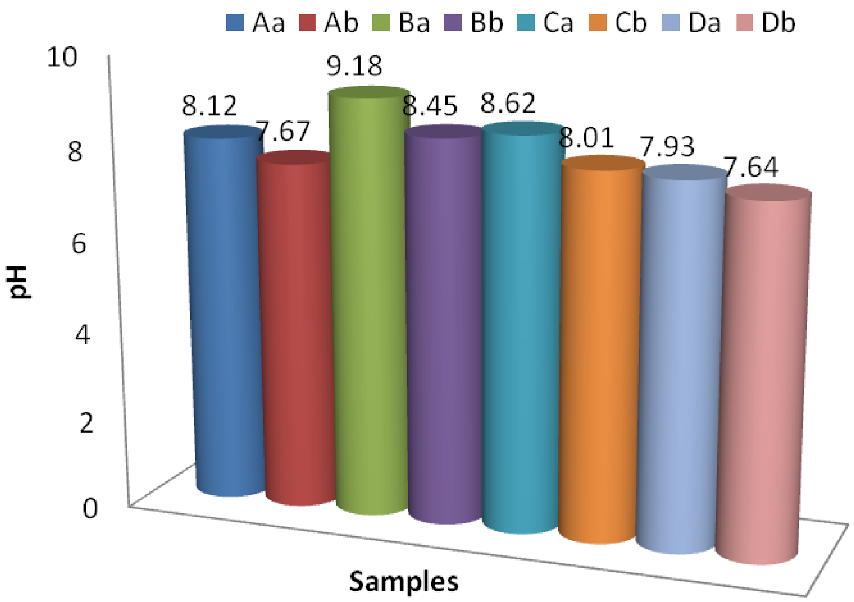

Figure 1. The pH content of sewage water from some selected areas in Port Harcourt metropolis, Rivers State.

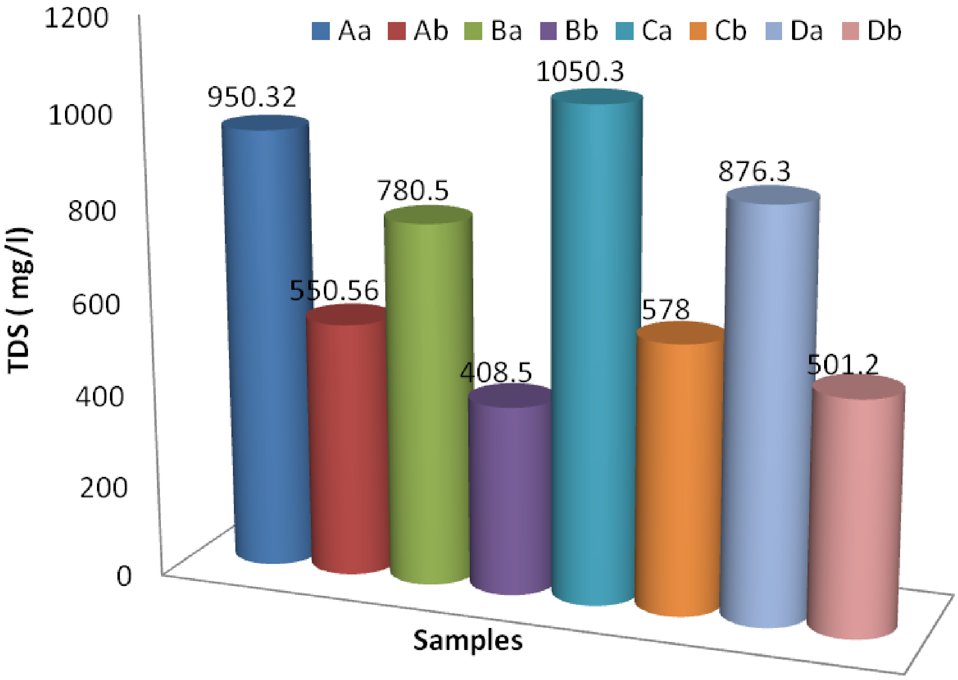

Figure 2. Total Dissolved Solid contents of sewage water from some selected areas in Port Harcourt metroplis, Rivers State.

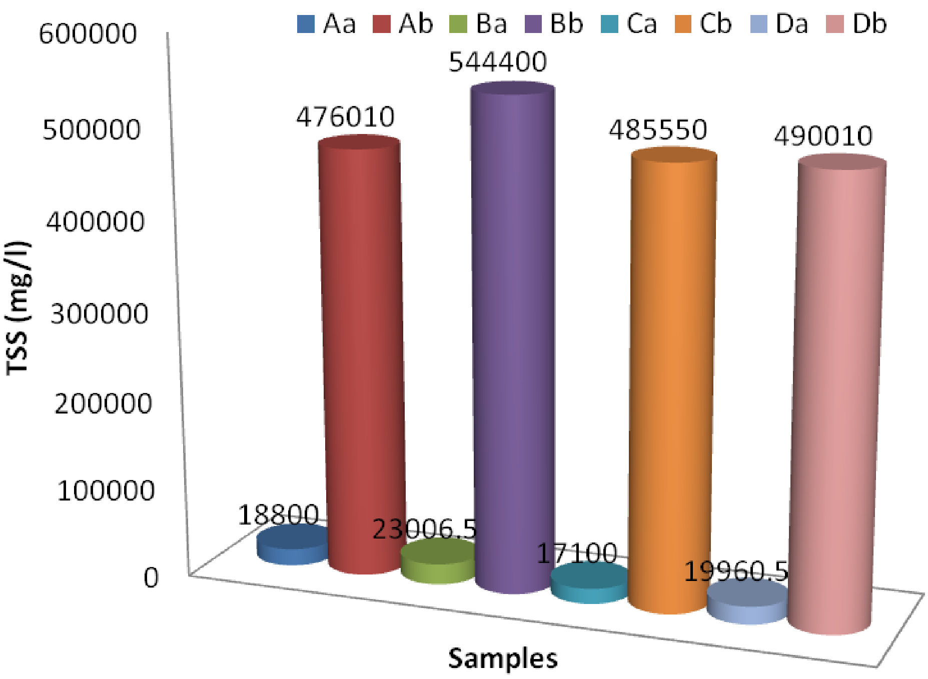

Figure 3. Total Suspendedd Solid Contents of Some selected sewage water from Port Harcourt metropolis, Rivers State.

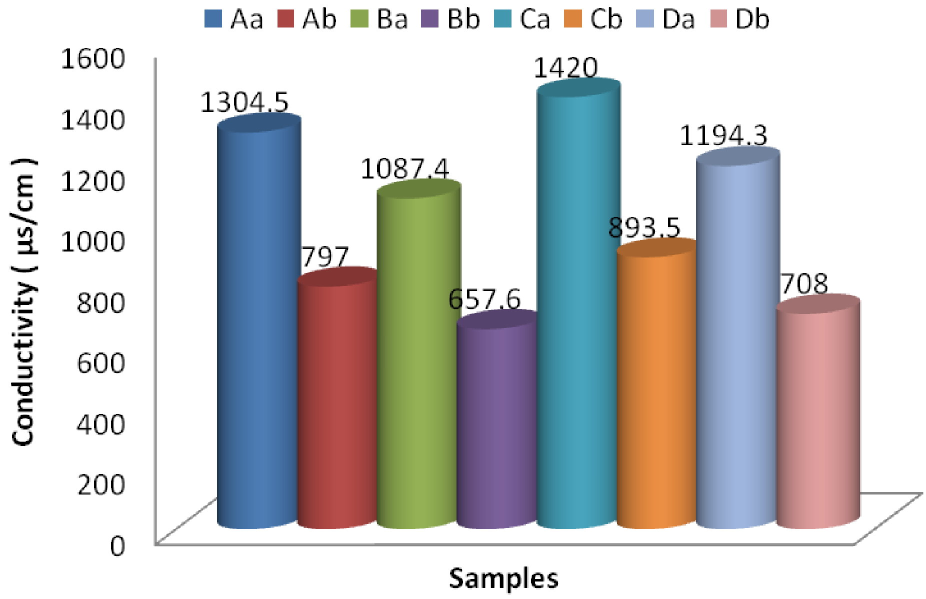

Figure 4. Conductivity in µs/cm of some selected sewage water from Port Harcourt metropolis, Rivers State.

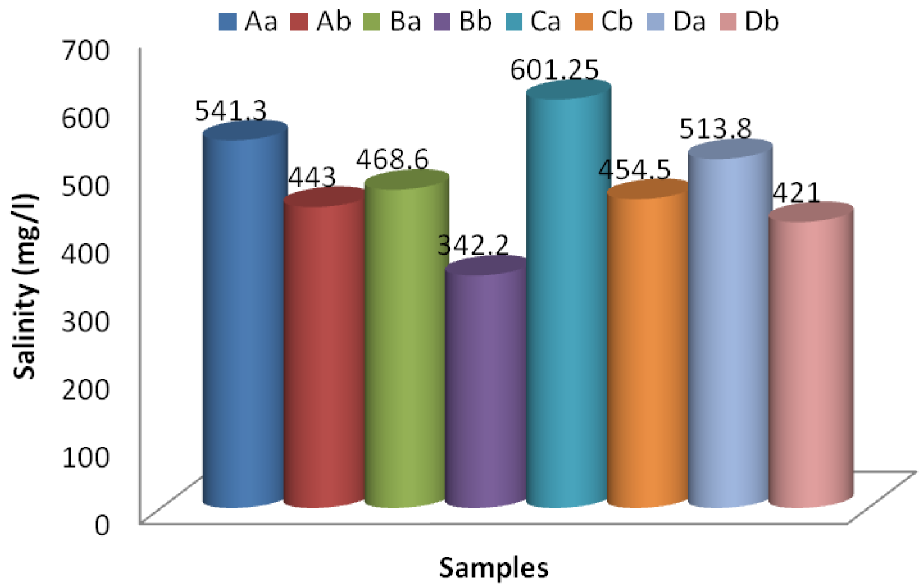

Figure 5. Salinity of sewage water of some selected areas of Port Harcourt metropolis, Rivers State, Nigeria.

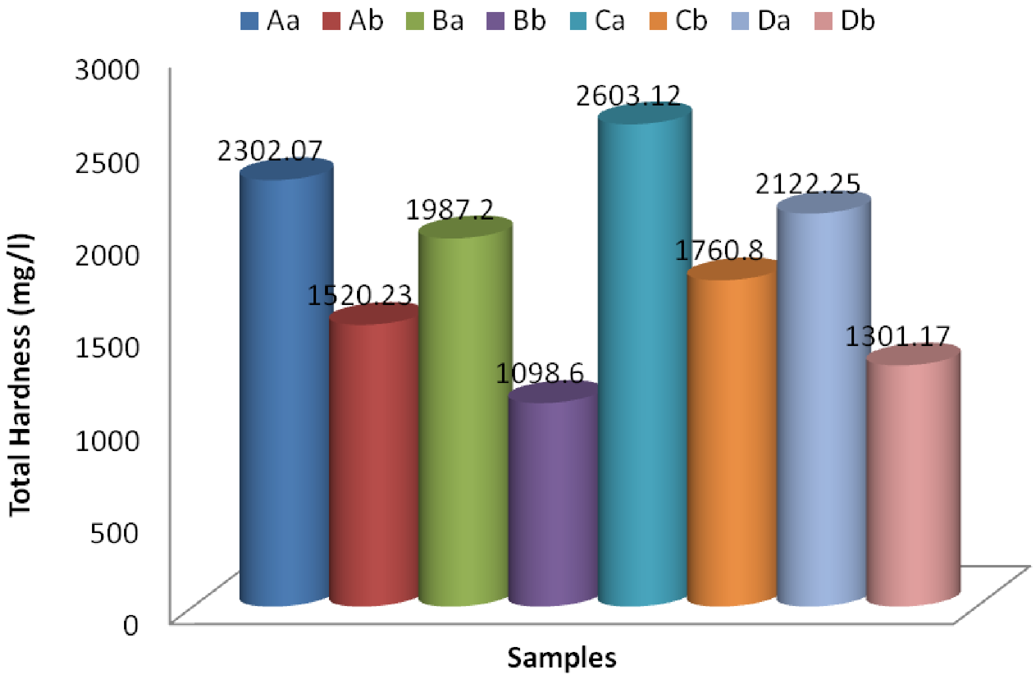

Figure 6. Total Hardness contnents of sewage water of some selected areas in Port Harcourt metropolis, Rivers State, Nigeria.

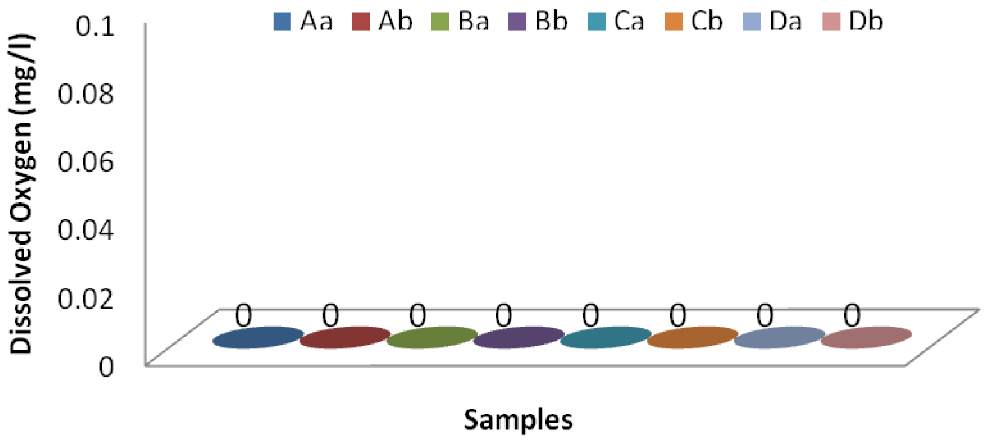

Figure 7. Dissolved Oxygen contents of sewage water of some selected areas in Port Harcourt metropolis, Rivers State, Nigeria

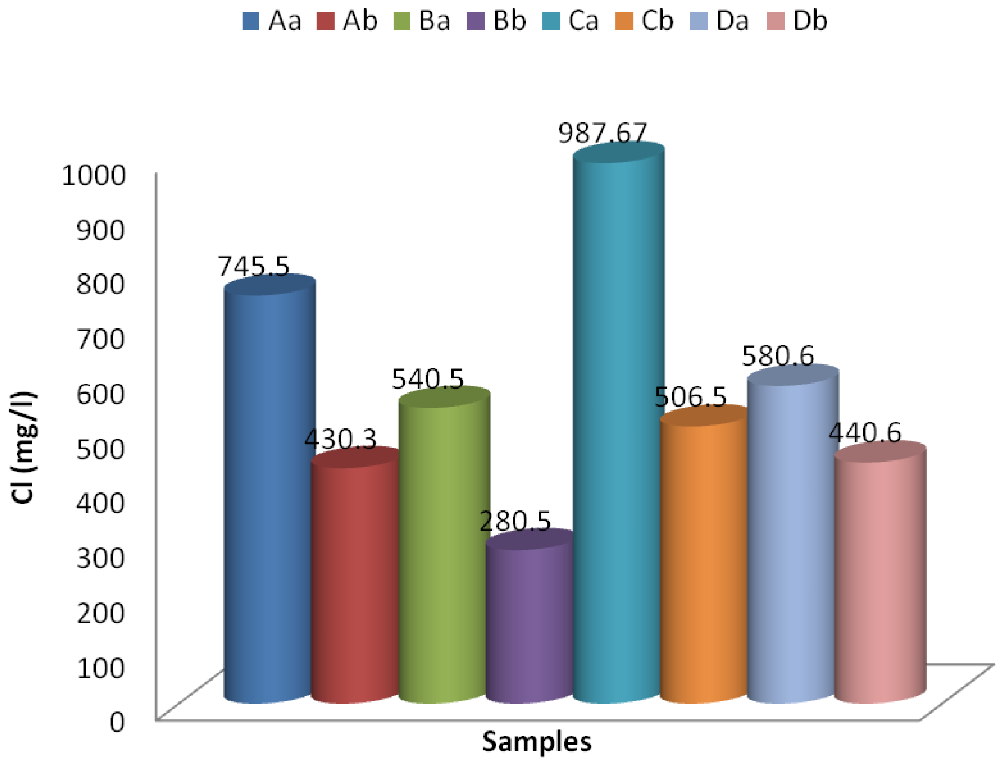

Figure 8. Cl contents of sewage sludge of some selected areas in Port Harcourt metropolis, Rivers State, Nigeria.

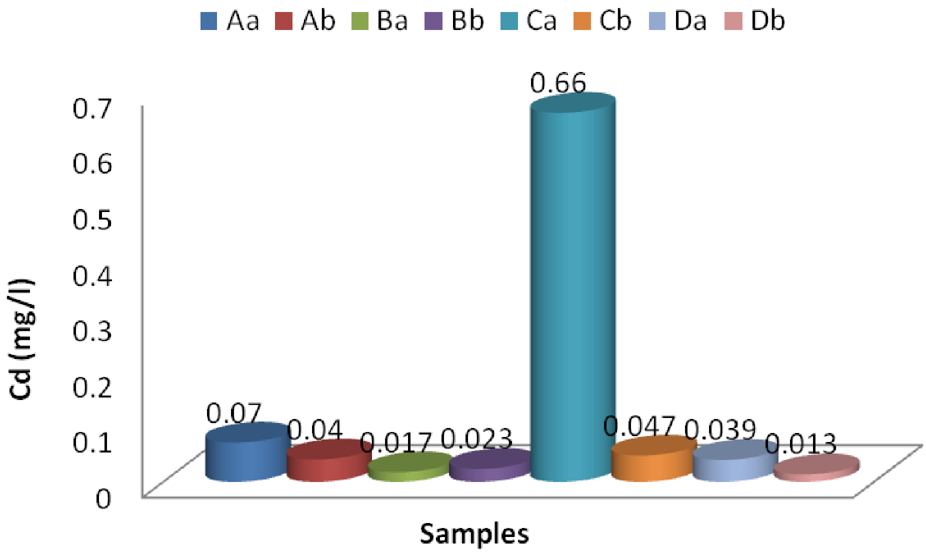

Figure 9. Cd contents of sewage water of some selected areas in Port Harcourt metropolis, Rivers State, Nigeria.

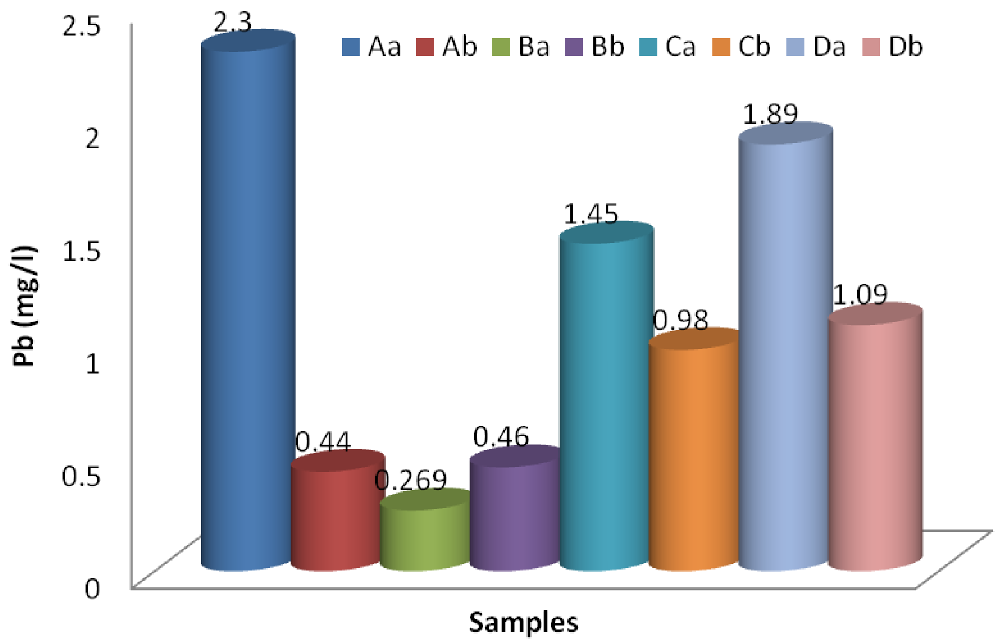

Figure 10. Pb contents of sewage water of some selected areas in Port Harcourt metropolis, Rivers State, Nigeria.

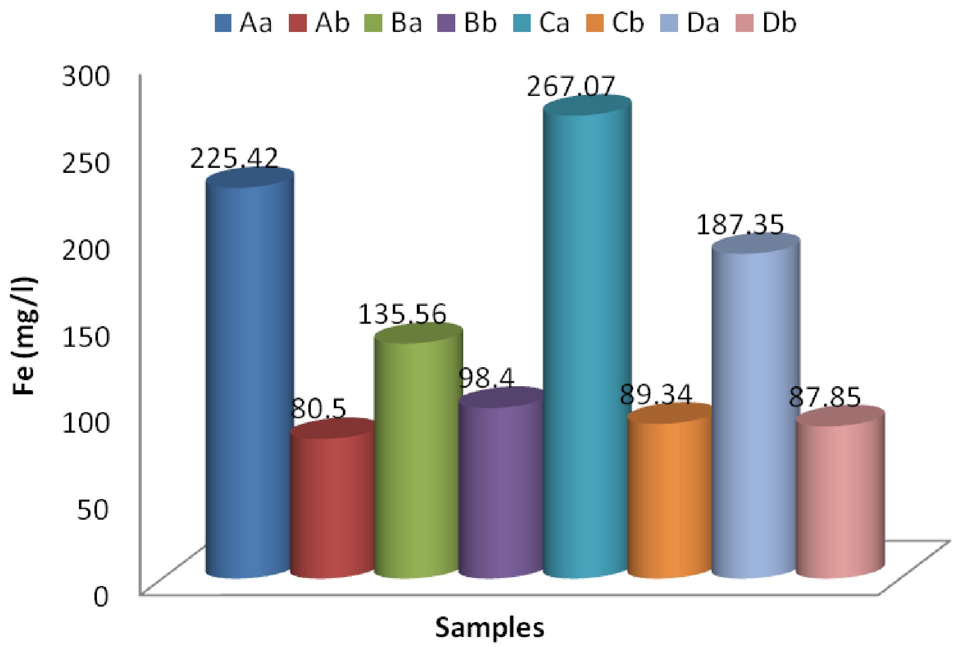

Figure 11. Fe contents of sewage water of some selected areas in Port Harcourt metropolis, Rivers State, Nigeria.

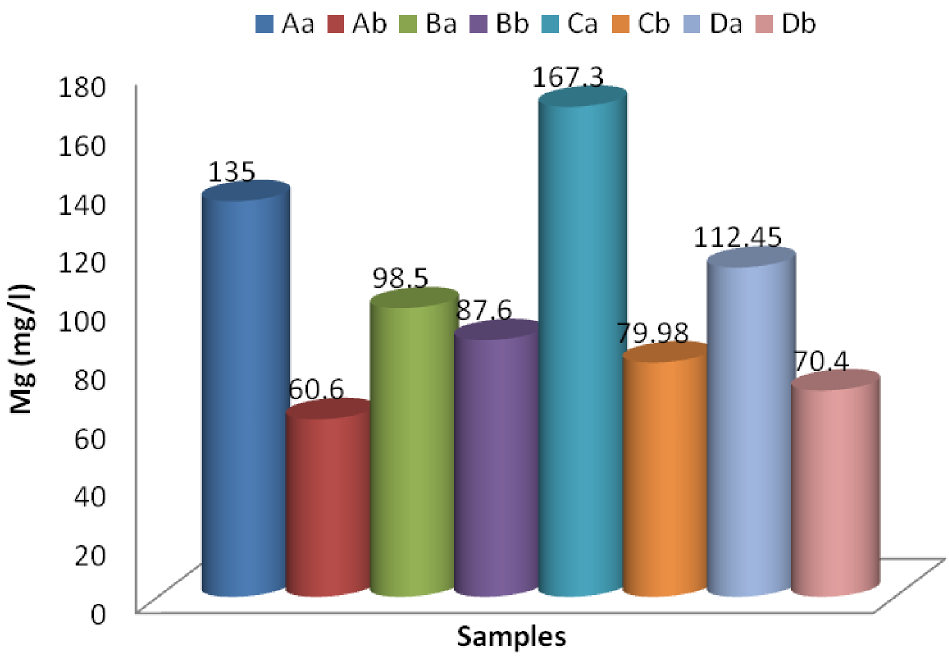

Figure 12. Mg contents of sewage water of some selected areas in Port Harcourt metropolis, Rivers State, Nigeria.

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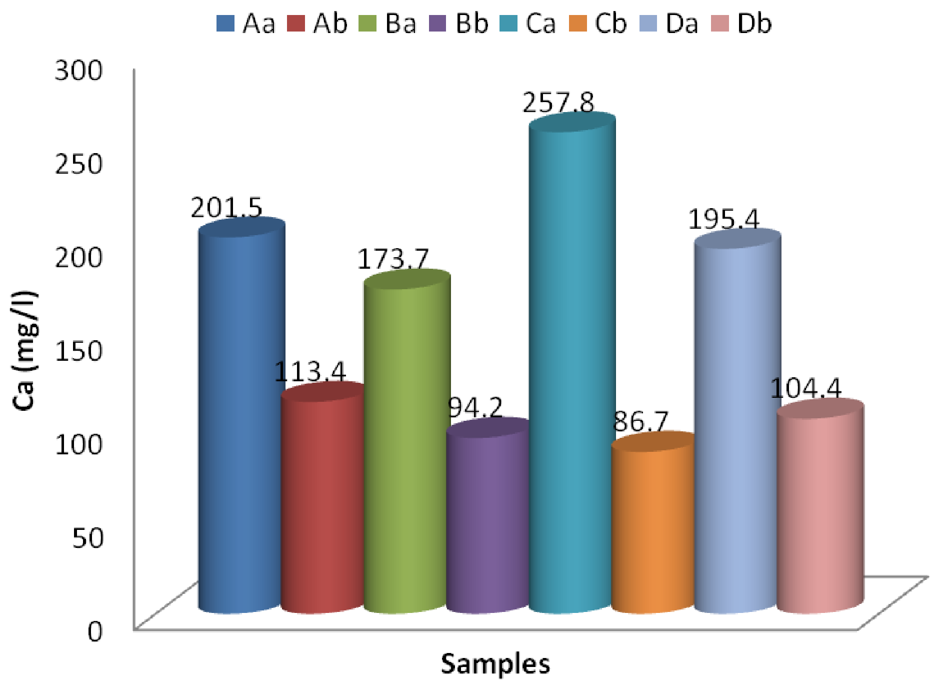

Figure 13. Ca contents of sewage water of some selected areas in Port Harcourt metropolis, Rivers State, Nigeria.

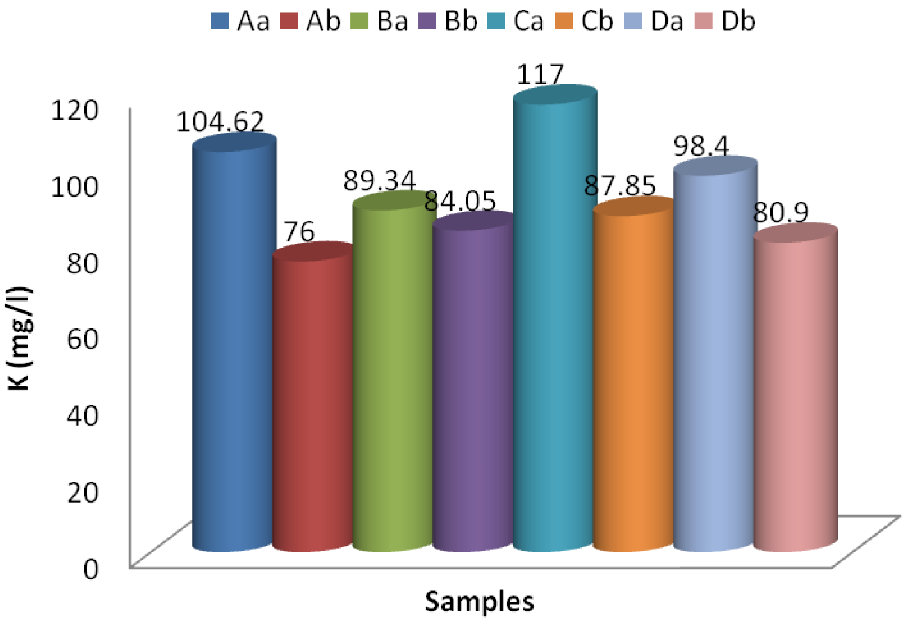

Figure 14. K contents of sewage water of some selected areas in Port Harcourt metropolis, Rivers State, Nigeria.

DISCUSSION

The physical parameters of the sewage from some selected areas in Port Harcourt metropolis, Rivers State, Nigeria were presented in Table 1 and Figure 1 – 4. The pH of the samples ranged from 7.67 ± 0.006 – 9.18 ± 0.008. Ba had the highest pH value (9.18 ± 0.008) while, Ab had the lowest value (7.67 ± 0.006). The increase in pH can be attributed to organic pollution, alkaline chemicals, soap and detergents produced due to commercial and residential activities. The pH of the samples are within the permissible limit (6.5 – 8.5) by W.H.O for aesthetic quality except sample Ba (9.18 ± 0.008) and Ca (8.62 ± 0.005). pH of the samples were similar to the range 8.0 – 9.4 reported by Krishnan *et al*., (2007). Total dissolved solids ranged from 408.50 ± 0.003 – 1050.30 ± 0.270 mg/l. Sample Ca had the highest content (1050.30 ± 0.270 mg/l) of total dissolved solids while Ba had the lowest content (408.50 ± 0.003). Total dissolved solids is a measure of the combined content of all inorganic and organic substances contained in molecular, ionized or micro granular suspended form. High total dissolved solids content generally indicate hard water, which can cause scale buildup in pipes, valves and filters. Threshold of accepted aesthetic criteria for human drinking water is 100 mg/l. Research has shown that exposure to high total dissolved solids is compounded in toxicity when other stressors are present, such as abnormal pH, high turbidly, or reduced dissolved oxygen with the latter stressor acting only in the case of anmaila. High total dissolved solids concentrations can produce laxative effects and can give an unpleasant mineral taste to water. High total dissolved solid concentrations are also unsuitable for many industrial applications. High total dissolved solids may also reduce water clarity, contribute to a decrease in photosynthesis, combine with toxic compounds and heavy metals and could lead to an increase in water temperature. Total suspended solids ranged from 17100.00 ± 0.230 – 544400.00 ± 0.430 mg/l. Bb had the highest concentration (544400.00 ± 0.430 mg/l) while Ca had the lowest concentration (17100.00 ± 0.230). The high amount of the total suspended solids is mainly due to the discharge of domestic waste (Palanivel and Rajaguru, 1999). High concentrations of suspended solids can cause many problems for stream health and aquatic life by blocking light from reaching submerged vegetation and reduces the rates of photosynthesis causes less dissolved oxygen to be released into the water by plants. If light is completely blocked from bottom dwelling plants, the plants will stop producing oxygen and will die. As the plants are decomposed, bacteria will use up even more oxygen from the water. High total suspended solids can also cause an increase in surface water temperature, because the suspended particles absorbed heat from sunlight. The conductivity of the samples ranged from 657.60 ± 0.300 – 1420.00 ± 0.500 µs/cm. Sample Ca had the highest conductivity (1420.00 ± 0.500 µs/cm) while Bb had the lowest conductivity (657.60 ± 0.300 µs/cm). Electric conductivity of

water is directly related to the concentration of dissolved ionized solids in the sewage. Ions from the dissolved solids in sewage water create the ability for the sewage to conduct an electrical current.

The chemical parameters of sewage samples investigated in this study were presented in Table 2 and figure 5 – 8. The salinity concentrations ranged from 342.200 ± 0.040 – 601.250 ± 0.650 mg/l. Ca had the highest salinity concentration (601.250 ± 0.650 mg/l) while Bb had the lowest (342.200 ± 0.040 mg/l) concentration of salinity might be due to discharge of domestic wastes containing high concentration of chlorides. The results of salinity obtained in this study were lower than the results reported by Krishnan *et al*., (2007).

The total hardness of the samples analyzed ranged from 1098.600 ± 0.300 – 2603.120 ± 0.500 mg/l. Sample Ca had the highest concentration (2603.120 ± 0.500 mg/l) while Db had the lowest concentration (1098.600 ± 0.300 mg/l). Total hardness represents the concentration of calcium and magnesium. The total hardness of the samples investigated were high when compared with the desirable limit which is 200 Mg/l in water as per ISI and higher than results obtained by Krishnan *et al*., (2007) and Roy and Kumar, (2002). Permanent hardness is mainly caused by chlorides and sulphates (Roy and Kumar, 2002). From the investigation carried out, dissolved oxygen was absent in the entire sample studied. This suggests that most of the discharges are organic in nature and hence require oxygen for decomposition. High decomposition of organic substances in sewage, indicate high pollution load and also reduces the dissolved oxygen. The deficiency of the oxygen in the samples is shelter for bacteria and other pathogens, which are anaerobic and injurious to human health. The results were similar to the results obtained by Krishnan *et al.,* (2007). The chloride contents ranged from 280.500 ± 0.120 – 987.670 ± 0.045 mg/l. Sample Ca had the highest chloride concentration (987.670 ± 0.045 mg/l) while Bb had the lowest Chloride concentration (280.500 ± 0.120 mg/l). The high concentration of chloride is due to dissolution of salts from domestic activities.

Trace metals contents of the samples investigated in this study were presented in table 3 and figure 9 – 11. The concentration of Pb ranged from 0.269 ± 0.006 – 2.300 ± 0.002 mg/l. Sample Aa had the highest concentration (2.300 ± 0.002 mg/l) while sample Ba had the lowest concentration (0.269 ± 0.006 mg/l). The concentration of Cd ranged from 0.013 ± 0.001 – 0.660 ± 0.002 mg/l. Sample Ca had the highest concentration (0.660 ± 0.002 mg/l) while sample Db had the lowest concentration (0.013 ± 0.001 mg/l). The concentration of Fe ranged from 80.500 ± 0.500 – 267.070 ± 0.250 mg/l. Sample Ca had the highest concentration (267.070 ± 0.250 mg/l) while Ab had the lowest concentration (80.500 ± 0.500 mg/l). Pb and Cd are heavy metals that accumulate in these samples and their concentrations exceeded the permissible limit. When the content of heavy metals exceeded the permitted threshold, they will impact the normal growth of crops or even might enter food chain to threat human and animal health (Akoumianakis *et al.,* 2009; Salvatore *et al.,* 2009). Zhang *et al*., (2008) and Zhang *et al.,* (2006) found that long-term sewage irrigation had effects on agricultural soil microbial structural and functional characterizations.

Macro metals concentrations of the samples investigated were presented in table 3 and figure 12 – 14. The concentrations of Mg ranged from 60.610 ± 0.200 – 167.320 ± 0.320 mg/l. Sample Ca had the highest concentration (167.320 ± 0.320 mg/l) while Ab had the lowest concentration had the lowest concentration (60.610 ± 0.200 mg/l). The results of this study exceeded the permissible limit (50 mg/l) and slightly higher than the results (60 – 110 mg/l) obtained by Subhadradevi *et al*., (2003). High concentration of Magnesium adversely affect domestic use of water. Calcium content ranged from 86.700 ± 0.160 – 257.800 ± 0.240 mg/l. Sample Ca had the highest content (257.800 ± 0.240 mg/l) while Cb had the lowest content (86.700 ± 0.160 mg/l). The permissible limit of calcium in water is 75 mg/l as per ISI. The results obtained exceeded the permissible limit. The concentration of calcium is high because of domestic discharges. The results obtained in this study were higher than results reported by Krishnan *et al*., (2007). The concentration of Potassium ranged from 76.200 ± 0.100 – 117.000 ± 0.650 mg/l. sample Ca had the highest concentration (117.000 ± 0.650 mg/l) while Ab had the lowest concentration (76.200 ± 0.100 mg/l). The increase in the concentration of these metals can be attributed to alkaline chemicals, soaps and detergents produced due to residential activities.

CONCLUSION.

The levels of the parameters investigated exceeded the permissible limit for domestic water purposes and fish production. The sewage water must be treated before disposed into the environment for avoiding health hazards.

REFERENCES

APHA (2000), *Standard methods for analysis of water and waste water*. American public Health Associated. Washington, D. C.

Abdel-Sabour, M.F. (2003), Impact of wastewater reuse on cobalt status in Egyptian environment. *J. Environ. Sci*. 15(3): 388 – 395.

Akoumianakis, K.A.., Passam, H.C., Barouchas, P.E. and Moustakas, N.K. (2009), Effect of cadmium on yield and cadmium concentration in the edible tissue of endive (Cichorium endive L.) and rocket (Eruca sativa Mill.). *J. Food Agr. Environ*. 6(3&4): 206 – 209.

Cuong, D.T. and Obdard, J.P. (2006), Metal speciation in coastal marine sediments from Singapore using a modified BCR- sequential extraction procedure. *Appl. Geochem*. 21(8):
1335 – 1346.

Gupta, N., Khan, D.K. and Santra, S.C. (2008), An assessment of heavy metal contamination in vegetables grown in wastewater – irrigated areas of Titagarh, West Bengal, India.B Environ. *Contam. Tox*. 80(2): 115 – 118.

He, Z.L., Yang, X.E. and Stoffella, P.J. (2005),Trace elements in agroecosystems and impacts on the environment. *J. Trace Elem. Med. Bio*. 19(2-3): 125 – 140.

Lu, Y., Gong, Z.T., Zhang, G.L. and Burghadt, W. (2003), Concentrations and chemical speciations of Cu, Zn, Pb, and Cr of urban soils in Nanjing, China. *Geoderma* 115(1-2): 101 – 111.

Maldonado, V.M. (2008), Heavy metal content in soils under different wastewater irrigation patterns in Chihuahua, mexico. *Int. J. Environ. Res. Public Health* 5(5): 441 – 449.

Nyamangara, J. (1998), Use of sequential extraction to evaluate Zinc and Copper in a soil amended with sewage sludge and inorganic metal salts. *Agr. Ecosyst. Environ*. 69(2): 135 – 141.

Palanivel, M. and P. Rajaguru (1999), The present status of the river Noyyal. Workshop on environmental status of rivers in Tamil Nadu, Bharathiar University. Coimbatore Press. pp.53-57.

Roy, Y. and R. A. Kumar (2002), A study of water quality of the rivers of Ranchi district. Ind. J. Environ. Protec., 21(5), 398-402.

R. Radha Krishnan, K. Dharmaraj and B.D. Ranjitha Kumari. (2007), A comparative study on the physicochemical and bacterial analysis of drinking, bore well and sewage water in the three different places of Sivakasi. *Jour. of Environ. Biol*. 28(1) 105-108.

Salvatore, M.D., Carratu, G. and Carafa, A.M. (2009), Assessment of heavy metals transfer from a moderately polluted soil into the edible parts of vegetables. *J. Food Agr. Environ*. 7(2): 683 – 688.

Subhadradevi, G., S.B. Barbuddhe, D. Hazel and C. Dolly (2003), Physicochemical characteristics of drinking water at Velseo, (Goa). *J. Ecotoxicol. Environ. Monit.*, 13(3), 203-209.

Tyagi, P., D. Buddi, R. Chowdary and R. Sawhney (2000), Physicochemical quality of Ground water in industrial areas of India. *Pollut. Res.*, 19, 443-445.

Trivedy, R.K. and P. K. Goel (1984), *Chemical and biological methods for water pollution studies*. Environmental Publications, Karad, India.

Walter, I., Bigeriego, M., and Calvo, R. (1994), *Invest. Agrar. Prod. Prot. Veg.*, 9, 501-507.

Yanggen, D.A. and S.M. Born (1990), Protecting ground water quality by managing local land use. *J. Soil Water Conser.*, 45 (2), 207-210

Zhang, Y.L., Dai, J.L., Wang, R.Q. and Zhang, J. (2008), Effects of long-term sewage irrigation on agricultural soil microbial structural and functional characterizations in Shandong, China. *Eur.J. Soil Biol*. 44(1): 84 – 91.

Zhang, Y., Zhang, H.W., Su, Z.C. and Zhang, C.G. (2006), Effect of sewage irrigation on the distribution of heavy metal, enzyme activities and microbial population in the soil. *J. Ssafety Environ.* 6(6): 44 – 50.

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